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Individual-based population dynamics model of delta smelt: comparing the effects of food versus entrainment.

Abstract: Actions to protect delta smelt have become increasingly controversial. To address some of the questions related to the causes of the decline, we developed an individual-based population dynamics model. The model tracks thousands of super-individuals on the same spatial grid as the DSM2 hydrodynamics model. Daily water temperature, salinity, and the densities of six zooplankton prey types are represented on the spatial grid. The model follows the reproduction, growth, mortality, and movement of individuals over their entire life cycle. Reproduction is evaluated daily and egg cohorts are tracked until hatching. New model individuals are introduced as individual yolk-sac larvae and tracked through a series of life stages. Growth of feeding stages is based on bioenergetics and zooplankton densities. Mortality includes a stage-specific constant rate, starvation, and entrainment. Movement of individuals is by particle tracking for the larval stages and behavioral algorithms for juveniles and adults. We simulated the population decline using 1995 to 2005 conditions, and explored the relative influence of historical changes in food and entrainment on delta smelt population dynamics. Historical food was simulated using zooplankton data from years during the 1970s to early 1980s matched to recent years by monthly flow or X2 patterns. Entrainment effects were simulated by repeating the 1995 to 2005 simulation but with entrainment eliminated. We repeated the simulations with alternative baseline assumptions of size-dependent mortality, fixed larval stage survival, maturity a function of length, and density-dependent juvenile mortality. Simulations indicated that the effect of entrainment on simulated delta smelt population growth rate was between 50% and equal to the effects of food; thus, both were important to the population decline. Increased understanding of how changes in food and entrainment affect delta smelt population dynamics will inform the protection and restoration of delta smelt.

Statement of Relevance: Quantitative analysis of the contribution of different factors to delta smelt population dynamics focuses the debate on clearly stated assumptions and scientific evidence. The modeling can be used to filter the possible management actions that could be taken, helping to identify effective and efficient options from an ecological perspective.